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Environmental Assessment and Control Technology for Low-Btu Gasification Works

Radian Corp.
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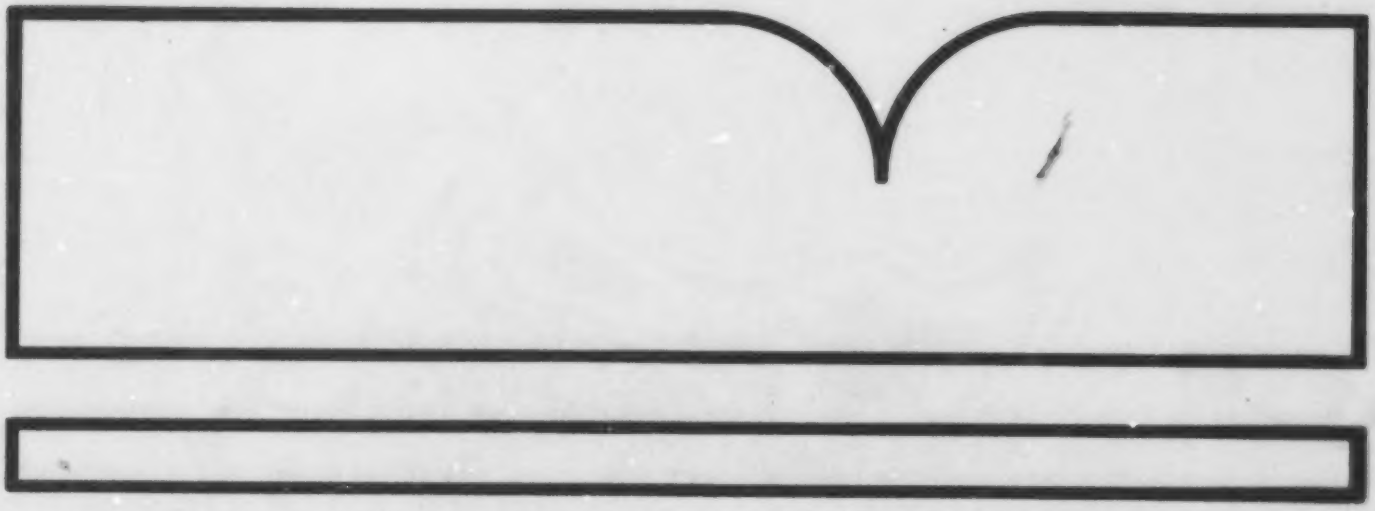

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16. ABSTRACT

The paper shows how EPA's Environmental Assessment (EA) methodology can be used to: (1) screen gaseous, liquid, and solid waste streams for potentially harmful health and ecological effects (Level 1); (2) prioritize the waste streams and their components for detailed analyses (Level 2); and (3) apply these data to the selection and evaluation of control technologies. To do this, chemical and biological data, collected during an environmental test program at a commercial-size Chapman low-Btu gasifier were used. The paper concludes that: (1) results of the SAM/IA analysis and bioassay screening tests compared favorably in most cases (exceptions included the gasifier ash and separator liquor); (2) results of the SAM/IA analysis and bioassay screening tests can be used to prioritize waste streams and their components for detailed analyses (Level 2); and (3) results of the deatiled analyses can be applied to the selection and evaluation of control technologies and to chemical parameters that need to be monitored in the control technology's waste streams for long-term health and ecological impact studies. Existing standards determine when a control technology is required and what pollutants need to be controlled.

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a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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Assessments	Stationary Sources	14B 07A
Coal Gasification	Environmental Assessment	13H
Coal Handling		15E
Coal Preparation	Low-Btu Gasification	08I
Sampling		
Analyzing		
Bioassay		
Gas Purification		

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Environmental Assessment and Control Technology for Low–Btu Gasification Works

The detailed analysis indicate the number of categories that may have harmful health and ecological effects were significantly less than shown in the screening analysis.

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INTRODUCTION

Radian Corporation of Austin, Texas, under a 3-year contract to the Environmental Protection Agency (EPA), is performing a comprehensive environmental assessment of low-Btu gasification technology. A major portion of this assessment involves source test and evaluation programs at commercial low-Btu gasification facilities. The objective of each program is to acquire necessary data for evaluation of: (1) environmental and health effects of multimedia waste streams from low-Btu gasification facilities, and (2) equipment required for control of problem waste streams.

The purpose of this paper is to show how EPA's Environmental Assessment Methodology can be used to (a) screen gaseous, liquid, and solid waste streams for potential harmful health and ecological effects (Level 1), (b) prioritize the waste streams and waste stream components for detailed analyses (Level 2), and (c) apply these data to the selection and evaluation of control technologies. To accomplish this, the chemical and biological data collected during the environmental test program at a commercial-size Chapman low-Btu gasification facility are used (Ref. 1).

The following text contains a brief discussion of the Chapman facility and the sampling and analysis methodology used during the test program. The methodologies used to evaluate the results of the program are also summarized, followed by the application of those methodologies in prioritizing waste streams and in selecting and evaluating a control technology.

PLANT DESCRIPTION

The Chapman gasification facility produces a low-Btu gas (5.9×10^6 J/Nm^3, 150 Btu/scf) which is used as combustion fuel for process heaters. The facility is equipped with 12 operational Chapman gasifiers. However, current fuel demands are low and are met by operating only two gasifiers at any specific time.

A block flow diagram of the Chapman facility is given in Figure 1. Major gaseous, liquid, and solid waste streams and feed streams are indicated.

Three operations are conducted at the Chapman facility: coal handling, gasification, and gas purification (particulate removal, and gas quenching and scrubbing). They consist of one or more discrete steps:

- Coal Handling - consists of delivery and storage of presized Virginia bituminous coal in hopper cars as well as conveying and storing the coal in the gasifier feed hoppers.
- Coal Gasification - consists of producing raw, low-Btu (5.9×10^6 J/Nm^3, 150 Btu/scf) gas from coal using fixed-bed, atmospheric pressure,

single-stage Chapman gasifiers. The coal enters the gasifier through a rotating feeder (barrel valve) and is spread across the bed by a distribution arm. The coal is then reacted with a steam/air mixture. Ash is collected in a water-sealed ash pan and removed by an ash plow. Pokeholes on top of the gasifier are opened periodically to permit the insertion of rods to break up any coal agglomerates that form in the gasifier and to measure the coal-bed depth.

- Gas Purification -

  - Particulate removal - consists of cyclonic removal of particulate matter from the hot, low-Btu gas. The particulate matter consists of devolatilized coal particles, tar, and ash.

  - Gas quenching and scrubbing - consists of removing tars and oils from the hot gas and cooling the gas to 320°K (120°F). The gas is cooled by in-line sprays followed by two tray scrubbers and a spray scrubber. Tar-laden quench liquor is sent to a tar/liquor separator where the tars settle to the bottom. The tars are removed periodically and used as an auxiliary fuel in a coal-fired boiler. The quench liquor is cooled and recycled to the gas quenching and scrubbing processes. Accumulated quench liquor is sent to a forced evaporator for treatment. Ideally, wastewater problems can be minimized by operating the gasifier so there is no net accumulation of water during the process. During the test period, no accumulated quench liquor was sent to the evaporator for treatment.

During the test program, stream flow rate data were collected to perform a total mass balance around the plant and to estimate emission rates. Table 1 shows the stream flow rates and overall mass balance. Approximately 90 percent of the total input mass was accounted for in the total mass exiting the plant.

SAMPLING AND ANALYSIS

The streams sampled during the test program and the analyses performed on each stream are summarized in Table 2. Detailed descriptions of the sampling and analytical methods are given in "Environmental Assessment: Source Test and Evaluation Report - Chapman Low-Btu Gasification" (Ref. 1) and "Guidelines for Preparing Environmental Test Plans for Coal Gasification Plants" (Ref. 2). Criteria for selecting streams for sampling included accessibility, plant operation, and potential for pollution. For example, the process heater flue gas was not sampled because the heater was located in a restricted area. Evaporator vapors were not sampled because no spent quench liquor was sent to the evaporator during the test.

DATA EVALUATION METHODOLOGIES

Two data evaluation techniques were used to assess the Level 1 chemical and biological test results and prioritize the waste streams and their chemical compounds in those streams for detailed chemical analysis (Level 2). These two techniques were:

- SAM/1A and
- Bioassay screening tests interpretation.

These techniques are summarized below.

SAM/1A - The Energy Assessment and Control Division of the EPA's Industrial Environmental Research Laboratory at Research Triangle Park (EACD/IERL-RTP) has developed a standardized methodology for interpreting Level 1 results obtained from environmental assessment test programs. This methodology uses Source Analysis Models (SAM's) (Ref. 3) in conjunction with the Multimedia Environmental Goals (MEG's) (Ref. 4).

The simplest number of the SAM's is SAM/1A. This model provides a rapid screening technique for identifying and prioritizing harmful waste streams. Major simplifying assumptions implicit in the use of the SAM/1A methodology are:

- The substances currently in the MEG's are the only ones that must be addressed at this time (The MEG's are currently being updated to include new data, account for new or revised standards, and add new compounds).
- Transport of the components in the waste streams to the external environment occurs without chemical or physical transformation of those components.

- Actual dispersion of a pollutant from a source to a receptor will be equal to, or greater than, the safety factors normally applied to acute toxicity data to convert these data to estimated safe chronic exposure levels.

- Discharge Multimedia Environmental Goal (DMEG) values (Ref. 4) developed for each substance are adequate for estimating acute toxicity. A DMEG is a concentration of a substance estimated to cause minimal adverse effects in a health receptor exposed once or intermittently for short periods. It relates either to human health or ecological effects.

- The waste stream components cause no synergistic effects.

These assumptions, along with the accuracy of the test data and assumptions used in developing DMEG values, must be considered when interpreting test results using a SAM/1A analysis scheme.

The following procedure was used in performing the SAM/1A analysis:

1) Determine the concentration of compounds or compound classes in the MEG categories (Ref. 4) for each stream.

2) Determine the health and ecological DMEG value (Ref. 4) of each component identified. In the case of a class of compounds, select the component with the lowest DMEG value. In selecting this component, determine if it can actually be present in the waste stream.

3) Calculate health and ecological Discharge Severity (DS) values for the components or compound classes in the waste stream. The following defines DS for component "i":

$$(DS)_i = (DC)_i/(DMEG)_i$$

where DC_i = stream concentration of component "i"

$DMEG_i$ = DMEG value of component "i" obtained from the MEG's (Ref. 4). Both health and ecological DMEG values are listed.

The DS values are used to prioritize stream components for detailed analysis.

4) Calculate the Total Stream Discharge Severity (TDS) by summing the DS values for all the individual components in the stream.

5) Calculate the Weighted Discharge Severity (WDS) for the total stream by multiplying the TDS by its mass flow rate.

The WDS for each stream is used subjectively in conjunction with the total stream bioassay test results to prioritize the streams for detailed analysis.

Bioassay Screening Tests - The bioassay screening tests used in the Chapman test program are shown in Table 3. The results of these tests were used along with the results of the SAM/1A analysis (i.e., DS_i and WDS) to prioritize the waste streams for Level 2 analysis.

At this stage of the methodology's development, prioritization is judgemental and depends on the expertise of the user. As more data become available, the meaning of the absolute values for TDS, WDS, and bioassay tests, in terms of real world effects, may be determined. Then, the prioritization may become more rigidly defined.

SAM/1A ANALYSIS RESULTS

The results of the SAM/1A analysis of the screening chemical data of the waste streams and potential fugitive emissions from the Chapman facility are shown in Table 4. All TDS's were significantly greater than 1. The gaseous waste streams and potential fugitive emissions had significantly greater TDS values than the solid waste streams. The WDS values for the gaseous emissions were also significantly higher than the WDS values for solid waste streams.

One aspect of using the SAM/1A technique is that usually one or two components represent over 90 percent of the Total Discharge Severity (TDS). Therefore, in reporting the SAM/1A results, all stream components and their respective MEG category with a DS greater than one should be reported. The basis used to calculate the compound health and ecological DMEG values should also be reported. The SAM/1A analysis for each stream show that the TDS values are usually dominated by only a few components (i.e., Benzo(a)pyrene for the coal feeder vent, separator vent, separator liquor and by-product tar). These data also show that the organic MEG categories

have significantly greater DS values than the inorganic categories. Also, many of the DMEG values for components in organic MEG categories are based on carcinogenicity, teratogenicity, and/or oncogenicity. Therefore, the results of the SAM/1A analysis indicate that detailed analyses (Level 2) should be performed on the organic fraction of each stream.

BIOASSAY SCREENING TEST RESULTS

In conjunction with screening chemical analyses, bioassay screening tests were performed on the plant's waste streams and potential fugitive emissions. The results of these tests are summarized in Table 5.

Before the bioassay test results can be used with the SAM/1A analysis results to prioritize streams for further detailed analyses, they must be interpreted with respect to potential health and ecological effects. The interpretation of the bioassay results were derived from the recommendations made by the Bioassay Subcommittee formed by IERL/RTP of EPA.

The general guidelines for interpreting the bioassay test results were as follows:

- High potential effect (only one of the following results are required to give a stream a high potential effect)
  - Positive Ames test
  - Significant toxic effects noted in the RAT test
  - Toxic effects in the aquatic tests
  - Significant toxic effects noted in the soil microcosm test (i.e., samples for which effects were equal to or greater than the by-product tar)
- Moderate potential effect
  - Slightly positive Ames test
  - Some toxic effects noted in the RAT test
- Low potential effect (all of the following results must be obtained)
  - Low cytotoxicity effects noted in the WI-38 and RAM tests
  - Low toxic effects noted in the RAT test
  - Low toxic effects noted in the soil microcosm test (i.e., samples with lower effects than the coal feedstock)
- No detectable effect (all of the following results must be obtained)
  - Negative Ames test
  - EC-50's not determined in the WI-38 and RAM tests
  - No detectable effects on plant's ethylene production

The results of the bioassay test interpretations are summarized in Table 6. They indicate that there may be a high potential for harmful health and/or ecological effects associated with all of the streams except the gasifier ash. It should be emphasized that interpretation of the bioassay results is currently very subjective. However, as more data are obtained, the basis of interpretation of these results will be more defined.

STREAM AND STREAM COMPONENTS PRIORITIZATION

The results of the SAM/1A analysis and the bioassay screening tests indicated that all streams may have potential harmful health and ecological effects. The SAM/1A analysis also indicated that the organics in the samples may have the greatest potential for affecting health and the environment. Therefore, Level 2 analyses were performed on the organic fractions of the samples. The analytical techniques used to identify organic compounds is discussed in detail in "Guidelines for Preparing Environmental Test Plans for Coal Gasification Plants" (Ref. 2).

DETAILED ANALYSIS (LEVEL 2) RESULTS

The detailed organic analyses identified compounds that may have potential harmful effects. However, the number of compounds and MEG categories that are of concern was greatly reduced from the evaluation of Level 1 results since Level 1 assumes a worst case component may be present. This is shown in Table 7. Also, the compound DS values that dominate the TDS either changed or were reduced after the Level 2 analyses as shown in Figure 2. Figure 2 shows the total DS for health and ecology separately. The TDS is the sum of these values.

APPLICATION OF CONTROL TECHNOLOGIES

The screening (Level 1) chemical and biological and the detailed (Level 2) chemical analyses portions of EPA's Environmental Assessment Methodology can be used (with

certain limitations) in the application of control technology. The following summarizes how these analyses can and cannot be applied to waste stream control technology.

- Results DO apply in the
  - Characterization of potentially harmful waste streams and compounds in those streams,
  - Selection of a control scheme to treat potentially harmful constituents, and
  - Definition of what parameters to monitor in the control technology's input and output streams.
- Results DO NOT apply in the
  - Definition of the level of control required for the pollutants in a waste stream, and
  - Determination of when a control is required.

For the do not apply areas, other criteria are used. These are defined by regulations, permitting agencies, and long-term health and environmental impact assessments. In these areas, the results described herein may still be utilized as an aid in decision making.

The following is an example of how the results can be applied to a control technology for treating the separator liquor. The liquor is first characterized with respect to identified compounds, trace elements, and water quality parameters and is then compared to existing standards. A potential control technique is then selected followed by a discussion of waste streams from that control.

Liquor Characterization - Table 8 shows the Consent Decree Pollutants along with other compounds with DS's greater than 1 that were identified in the separator liquor. Fifteen Consent Decree Pollutants were identified along with five additional compounds having a DS greater than 1. Water quality parameters for the liquor were also determined. These parameters are compared to the most stringent federal and state standards in Table 9. All of the liquor's parameters exceeded the values for most stringent standards. Therefore, treatment of this liquor would be required before disposal.

Selection of Control Technology - Comparing the chemical data for the separator liquor to the standards presented in Tables 8 and 9, control of both organics and inorganics will be needed. The flow rate of this stream will be quite small (3.79×10^{-4} to 1.52×10^{-4} m^3/sec, 5 to 20 gpm) and will depend upon the plant's size and operating parameters (e.g., steam input to the gasifier and outlet temperature of the product gas). To treat small quantities of separator liquor, a possible control scheme may be to concentrate the liquor using forced evaporation and to dispose of the concentrate using the proposed waste disposal guidelines under the Resource Conservation and Recovery Act (Ref. 5).

Control Effluent Monitoring - If a forced evaporation technique is employed to treat the spent separator liquor, the gaseous emissions and the concentrate should be monitored. Species that may be monitored include those covered by standards and those that may have potential harmful health and ecological effects. Gaseous emissions should be monitored for ammonia, cyanides, and the organic compounds listed in Table 8. Monitoring of the concentrate should include its flow rate, trace elements, organic species, and any biological tests proposed in Ref. 5. These monitoring data could also be used in long-term environmental impact studies for compounds which may have potential harmful health and ecological effects.

CONCLUSIONS

The conclusions concerning the use of EPA's methodology for screening waste streams (SAM/1A and bioassay tests), performing detailed analysis (Level 2), and applying those data to control technology are as follows:

- The results of the SAM/1A analysis and bioassay screening tests compared favorably in most cases. Exceptions were noted for the gasifier ash and separator liquor. For the ash, the ecological DS value indicated that the ash may have the same potential effects as the cyclone dust while the bioassay tests indicated a much lower potential for harmful effects than the dust. The health DS for the separator liquor indicated a moderate to high potential for harmful effects while the health bioassay tests indicated a low potential. The reasons for these discrepancies are currently under investigation.
- The results of the SAM/1A analysis and bioassay screening tests can be

used to prioritize waste streams and waste stream components for detailed analyses (Level 2). The detailed analyses performed indicated the number of components and compound classes (MEG categories) that may have potential harmful health and ecological effects were significantly less than the results from the screening (Level 1) analysis.

- The results of the detailed analyses can be applied to the selection and evaluation of control technologies and to the possible chemical parameters that need to be monitored in the control technology's waste streams for long-term health and ecological impact studies. It should be emphasized that existing standards determine when a control technology is required and what pollutants need to be controlled.

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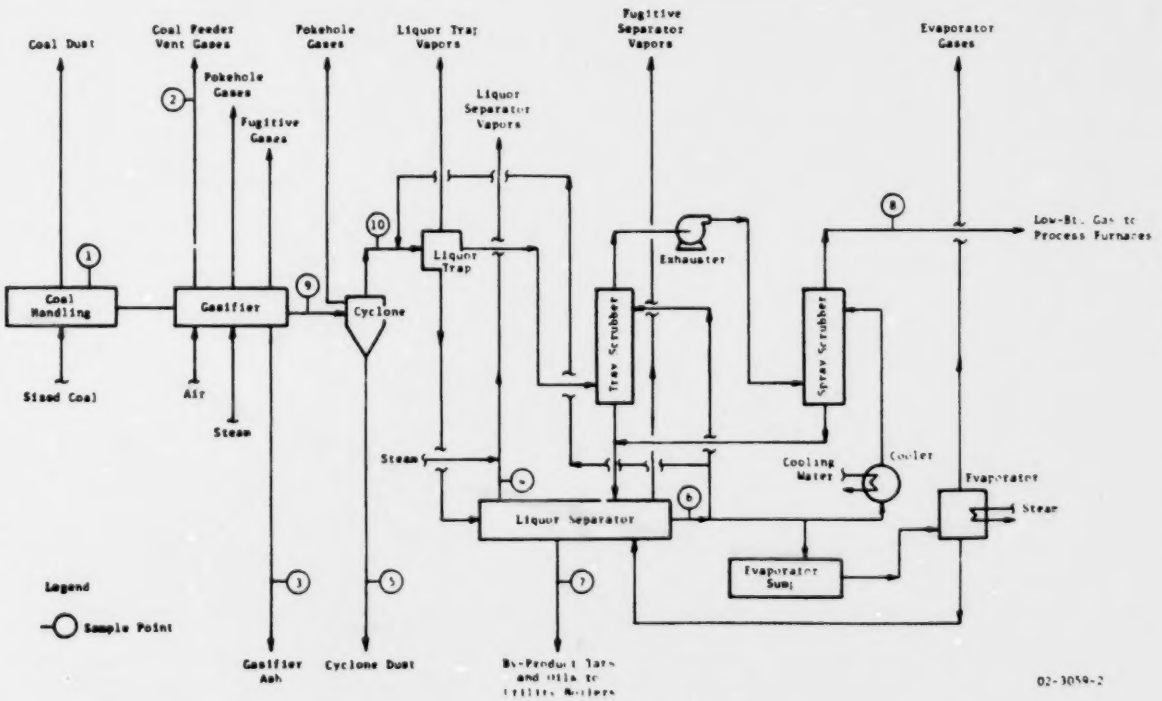

Figure 1. Simplified process flow diagram for the Chapman facility showing sampling points and gaseous, liquid, and solid waste streams.

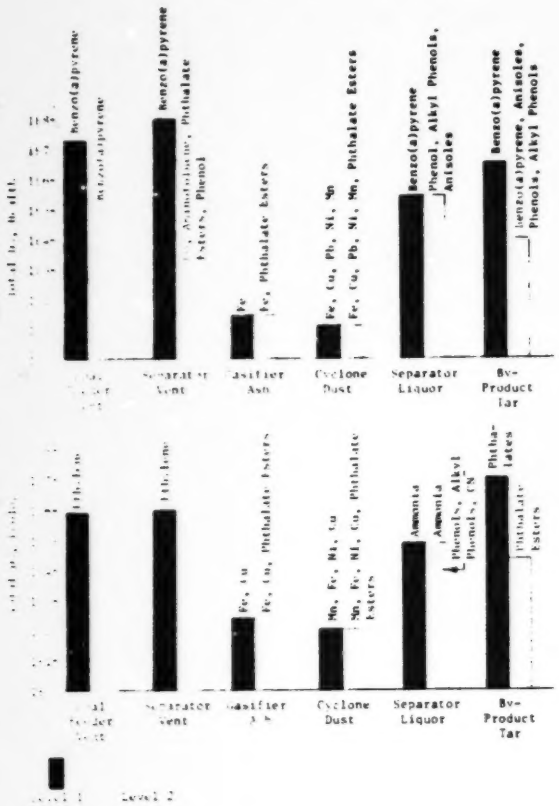

Figure 2. Level 1 and 2 stream DS values and dominating compounds

TABLE 1. MASS BALANCE AROUND THE CHAPMAN GASIFICATION FACILITY

Input Streams	Flow Rate (kg/hr)
- Gaseous	
• Air	2772
• Steam	576
- Solid	
• Coal	1094
TOTAL INPUT	4442
Output Streams	
- Gaseous	
• Coal Feeder Vent	22
• Separator Vent	194
• Product Gas	3560
- Liquid	
• By-Product Tar	109
- Solid	
• Gasifier Ash	67
• Cyclone Dust	6
TOTAL OUTPUT	3958
(Output/Input) x 100	89%

TABLE 2. SAMPLING AND ANALYSIS SUMMARY FOR THE CHAPMAN FACILITY TEST PROGRAM

Stream Sampled	Level 1 Chemical & Biological	Level 2 Chemical	Additional Analysis
Coal Feed	-	-	Proximate/Ultimate
Coal Feeder Vent	x	x	-
Gasifier Ash	x	x	Proximate/Ultimate
Cyclone Dust	x	x	Proximate/Ultimate
Separator Vent	x	x	-
By-Product Tar	x	x	Proximate/Ultimate
Separator Liquor	x	x	-
Raw Product Gas	-	-	Fixed Gases, Sulfur Species, NH_3, HCN, C_1 - C_6 Hydrocarbons
Clean Product Gas	-	-	

Fixed Gases: H_2, CO, CO_2, N_2, O_2, CH_4

Sulfur Species: H_2S, COS, CS_2, SO_2

x = Analyses performed

- = No analyses performed

TABLE 3. BIOASSAY SCREENING TESTS AND RESPONSES

Bioassay Test	Biological Response
Health Tests	
• Ames	Potential mutagenicity (carcinogenicity)
• WI-38	Acute cellular toxicity
• RAM	Acute cellular toxicity
• RAT	Acute toxicity (whole animal)
Aquatic Tests	
• Fresh water (algae, daphnia, and fathead minnow) tests	Toxicity
• Salt water (algae, grass anrimp, and sheepshead minnow) tests	Toxicity
Terrestrial Tests	
• Soil microcosm	Toxicity (ranking only)
• Plant stress ethylene	Toxicity

TABLE 4. RESULTS OF THE SAM/1A ANALYSIS OF THE CHEMICAL SCREENING DATA

	DS*		WDS*	
	Health	Ecological	Health	Ecological
Gaseous Waste Streams				
Coal Feeder Vent Gas	4E7	8E5	2E6 (m^3/sec)	5E4 (m^3/sec)
Separator Vent Gas	1E8	1E6	6E7 (m^3/sec)	6E5 (m^3/sec)
Solid Waste Stream				
Cyclone Dust	2E1	2E2	3E1 (g/sec)	3E2 (g/sec)
Gasifier Ash	5E1	4E2	9E2 (g/sec)	7E3 (g/sec)
Potential Fugitive Emissions				
Raw Product Gas	4E8	8E5		
Separator Liquor	3E5	2E5		
By-Product Tar	5E6	1E7		

* $aEb = a \times 10^b$

DS: Discharge Severity

WDS: Weighted Discharge Severity

TABLE 5. BIOASSAY TEST RESULTS FOR THE CHAPMAN COAL GASIFICATION FACILITY

	Coal Feed (s)	Coal Feeder Vent Gas* (g)	Coal Feeder Vent Gas XAD-2 Extract*(g)	Gasifier Ash*(s)	Cyclone Dust*(s)	By-Product Tar(s)	Separator Vent Gas XAD-2 Extract*(g)	Separator Liquor (l)
HEALTH TESTS								
1. Ames	SP	-	P	N	N	P	SP	N
2. Cytotoxicity[a]								
WI-38, EC_{50} (cell count, µg solid, m^3 gas/ml culture)	>60	-	4×10^{-4}	-	-	-	7×10^{-4}	-
RAM, EC_{50} (cell count, µg solid & liquid, m^3 gas/ml culture)	>1000	-	$>2 \times 10^{-3}$	>300	>1000	>1000	$>1 \times 10^{-3}$	>600
3. Rodent Acute Toxicity	M	-	-	L	M	H	-	L
LD_{50} (g sample/kg rat)	>10	-	-	>10	>10	>10	-	>10
ECOLOGICAL TESTS								
Fresh Water[b]								
Algal, EC_{50} (15 days)	-	-	-	-	-	-	-	1.0 to 0.1%
Daphnia, LC_{50} (48 hours)	-	-	-	-	-	-	-	0.11%
Fathead minnow, LC_{50} (96 hours)	-	-	-	-	-	-	-	0.02%
Salt Water[b]								
Algal, EC_{50} (12 days) filter/unfiltered	-	-	-	-	-	-	-	0.53/0.41%
Shrimp, LC_{50} (96 hours)	-	-	-	-	-	-	-	0.25%
Sheepshead minnows, LC_{50} (96 hours)	-	-	-	-	-	-	-	0.16%
Terrestrial								
Soil microcosm[c]	3	-	-	4	1	2	-	5
Plant stress ethylene	-	M	-	-	-	-	-	-

*Indicates a plant waste stream

SP: Slightly positive

P: Positive

N: Negative

(g): gas, (s): solid, (l): liquid

H: High toxicity

M: Medium toxicity (i.e., rats showed hair loss, eye discoloration, etc.)

L: Low toxicity (i.e., no significant effects noted)

EC_{50}: Concentration at which growth was 50 percent of a control

LC_{50}: Concentration at which 50 percent of the experimental animals died

LD_{50}: Dose per kg of test animal at which 50 percent died.

[a] EC_{50}'s were calculated on the XAD-2 extract for the coal feeder and separator vent gases by:

$$EC_{50} = \left[\begin{array}{c}EC_{50} \text{ reported} \\ \text{in µl of extract} \\ \text{per ml culture}\end{array}\right] \times \left[\begin{array}{c}\text{mg of organics} \\ \text{extracted per ml} \\ \text{of extract}\end{array}\right] \div \left[\begin{array}{c}\text{mg of organics} \\ \text{per } Nm^3 \text{ of} \\ \text{vent gas}\end{array}\right] = Nm^3 \text{ vent gas/ml culture}$$

[b] EC_{50}'s and LC_{50}'s for fresh and salt water tests are presented in wt% of the sample in water.

[c] Soil microcosm tests are ranked from No. 1, the most toxic, to No. 5, the least tox

TABLE 6. INTERPRETATION OF THE BIOASSAY TEST RESULTS ON THE CHAPMAN FACILITIES WASTE STREAMS AND POTENTIAL FUGITIVE EMISSIONS

Bioassay Test	Plant Waste Streams and Potential Fugitive Emissions						
	Coal Feed	Coal Feeder Vent	Gasifier Ash	Cyclone Dust	By-Product Tar	Separator Vent	Separator Liquor
Health							
• Ames	M	H	ND	ND	H	M	ND
• WI-38	ND	L	-	-	-	L	-
• RAM	ND	ND	ND	ND	ND	ND	ND
• RAT	M	-	L	M	H	-	L
Freshwater							
• Algal	-	-	-	-	-	-	H
• Daphnia	-	-	-	-	-	-	H
• Fathead Minnow	-	-	-	-	-	-	H
Saltwater							
• Algal	-	-	-	-	-	-	H
• Shrimp	-	-	-	-	-	-	H
• Sheepshead Minnow	-	-	-	-	-	-	H
Terrestrial							
• Soil Microcosm	M	-	L	H	H	-	L
• Plant Stress Ethylene	-	ND	-	-	-	-	-

-: Test not performed
H: High
M: Moderate
L: Low
ND: Not detectable

TABLE 7. MEG CATEGORIES WITH DS > FOR LEVEL 1 AND 2 ORGANIC ANALYSES

MEG Categories	Coal Feeder Vent		Separator Vent		By-Product Tar		Separator Liquor		Gasifier Ash		Cyclone Dust	
	Level 1	2	Level 1	2	Level 1	2	Level 1	2	Level 1	2	Level 1	2
1. Aliphatics	x	x	x	x	x							
2. Alkyl Halides			x		x				x		x	
4. Halogenated Ethers									x		x	
6. Glycols, Epoxides							x					
7. Aldehydes, Ketones											x	
8. Carboxylic Acids	x	x	x	x	x	x		x	x	x	x	x
10. Amines	x	x	x	x	x	x		x			x	
13. Thiols, Sulfides	x						x					
14. Sulfonic Acid	x											
15. Benzene	x			x	x	x						
16. Halogenated Aromatics									x		x	
18. Phenols	x		x	x	x	x	x	x	x		x	
19. Halogenated Phenols									x		x	
20. Nitrophenols									x		x	
21. Fused Polycyclics	x	x	x	x	x	x	x	x	x		x	
23. Heterocyclic N	x		x		x		x					
24. Heterocyclic O	x		x		x		x					
25. Heterocyclic S	x		x		x		x					
TOTAL	11	4	9	6	10	5	7	4	8	1	10	1

TABLE 8. COMPONENTS WITH DS'S >1 AND CONSENT DECREE POLLUTANTS IDENTIFIED IN THE SEPARATOR LIQUOR

MEG Category	Compound Identified	Estimated Stream Concentration (µg/ℓ)*	DS Value*		Consent Decree Pollutant
			Health	Ecological	
(1) Aliphatics	>C_6 Alkanes	1E5	<1	1E0	No
(8) Carboxylic Acids	Phthalates	2E4	<1	1E4	Yes
(10) Amines	Aniline	3E3	<1	3E0	No
	Aminotoluene	4E3	2E0	NA	No
(18) Phenols	Phenol	7E5	1E5	1E3	Yes
	Anisoles	1E6	3E5	3E3	No
	Alkylphenols	4E5	8E4	8E2	Yes
(21) Fused Polycyclics	Naphthalene	2E4	<1	2E2	Yes
	Acenaphthalene	4E3	<1	<1	Yes
	Benzoperylene	3E4	NA	NA	Yes
(47) Nitrogen	Ammonia	5E6	2E3	1E5	Yes
	Cyanide	1E6	2E3	4E4	Yes
(49) Arsenic	As	8E2	3E0	2E1	Yes
(50) Antimony	Sb	7E1	<1	<1	Yes
(54) Selenium	Se	2E3	4E1	8E1	Yes
(72) Iron	Fe	1E3	<1	4E0	No
(78) Copper	Cu	1E1	<1	<1	Yes
(79) Silver	Ag	2E0	<1	<1	Yes
(82) Cadmium	Cd	5E0	<1	5E0	Yes
(83) Mercury	Hg	<3E4	<1	<1	Yes

*Stream concentrations and DS values; aEb = a x 10^b

NA - DMEG value not available

TABLE 9. WATER QUALITY PARAMETERS FOR THE SEPARATOR LIQUOR VS. MOST STRINGENT REGULATIONS

Water Quality Parameter	Concentration (µg/mℓ)	Most Stringent Regulations (µg/mℓ)
CN^-	1,000	0.02
Cl^-	3,000	250
F^-	200	1
$SO_4^=$	1,000	600
PO_4^{-3} (as P)	20	1.0[a]
NH_4^+ (as N)	5,000	2.5
BOD	6,530	30[b]
COD	22,200	125
TSS	144	15 or 37

[a]Regulation for phosphorous containing compounds

[b]Deoxygenating wastes

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